State of Montana

Proposal

for

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

VOLUME ONE: THE PROPOSAL

March 1, 1991

Presented To:

LIGO Project
Mail Code 102-33
Attention: LIGO Site Solicitation
California Institute of Technology
Pasadena, CA 91125

ERRATA

Volume One

Figures 2.1 and 2.2 are not included in this copy of the proposal, due to the unavailability of sufficient copies at the time of delivery. These Figures were included in the original and four copies submitted to the California Institute of Technology:

Figure 2.1 is a 7.5 minute United States Geological Survey Topographic Quadrangle titled "Comanche, Montana;" it bears an indication of one observatory location/orientation, with the vertex located in the Northeast quarter of Section 2, Township 2 North, Range 23 East, Montana Prime Meridian.

Figure 2.2, Part 1 is a 1:250,000 scale United States Geological Survey Topographic Map titled "Billings, Montana; Wyoming."

Figure 2.2, Part 2 is a 1:250,000 scale United States Geological Survey Topographic Map titled "Roundup, Montana."

Volume Three

Page B-69 of the original and four copies submitted to the California Institute of Technology was followed by a book titled "Montana: On the Cutting Edge of Technology," produced by the Montana Power Company. Additional copies of the book, which provides company profiles on several Montana technology-based firms, may be obtained from:

James B. Smitham, Marketing Department
Montana Power Company
40 E. Broadway
Butte, MT 59701
Telephone:(406)723-5421, Extension 2773

PREFACE

We are pleased to present this Proposal to the California Institute of Technology for location of the Laser Interferometer Gravitational Wave Observatory (LIGO) at Comanche Basin, Montana. We believe the LIGO Project provides an outstanding opportunity for advanced understanding of our universe, and that a Montana location will serve the scientific goals exceptionally well; further, the Montana Proposal can provide significant economic savings through reduced acquisition and preparation costs due to the site's relative isolation and absence of significant population and housing requiring relocation.

This proposal was prepared through a cooperative effort of the Governor of the State of Montana, the Montana Department of Commerce, the Vice-President for Research at Montana State University, the Physics Department at Montana State University, the Earth Sciences Department at Montana State University, the Museum of the Rockies, the Montana Science and Technology Alliance, Montanans on a New Track for Science, the Gallatin Development Corporation, and the Billings Chamber of Commerce. Each of these parties provided valuable assistance in their respective fields of expertise; we appreciate their contributions.

Selection of Comanche Basin as the proposed site was based on LIGO criteria included in the November 20, 1990 Site Solicitation Announcement. Much of the geotechnical information included in this proposal was obtained during studies conducted for the State of Montana Proposal for the U.S. Department of Energy Superconducting Supercollider in 1987. While Comanche Basin was not chosen for the Supercollider Project, we believe the principal reason was not related to site suitability but rather to the ability of the local area to accommodate the estimated work force associated with construction and operation of that facility. LIGO represents a much smaller construction and operation work force which will be readily absorbed by the communities.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF FIGURES

THE PROPOSAL

I. The National Science Foundation, California Institute of Technology, and Massachusetts Institute of Technology select Comanche Basin, Montana for the construction of one (1) Laser Interferometer Gravitational Wave Observatory.

II. The State of Montana, in cooperation with Montana State University and the LIGO Project, will provide assistance in securing additional geotechnical information as required to qualify the proposed site (Comanche Basin) and prepare engineering and construction plans.

Montana State University will make available its Departments of Earth Sciences, Architecture, Civil Engineering, and Plant and Soil Sciences to cooperate with the LIGO Project in this effort.

III. The State of Montana, through its executive branch, will assist in the assembly and acquisition of title and/or long-term easement to the lands required for LIGO facilities and access roads.

IV. In cases where acquisition requires purchase of lands or easements creating a budget overrun in the site acquisition and preparation line item, the Governor of the State of Montana will call into Special Session the Legislature of the State to appropriate required funds to complete the acquisition and redress the budgetary issue.

THE PROPOSAL (continued)

V. The Montana University System and Montana State University will provide the faculty additions described in this proposal in support of gravity physics research.

VI. This offer is valid for a period of 180 days beginning March 1, 1991.

SIGNED AND DATED THIS ____ DAY OF FEBRUARY, 1991:

STAN STEPHENS
Governor
State of Montana

DAVID S. TOPPEN
Deputy Commissioner for
Academic Affairs
Montana University System

ELBERT "BUTCH" OTT
President/CEO
Billings Area Chamber
of Commerce

DIXIE F. SWENSON
Executive Director
Gallatin Development Corp.

DR. ROBERT J. SWENSON
Vice-President for Research
Montana State University

THE SITE - COMANCHE BASIN

GENERAL

The proposed location of the observatory in Montana is in Southcentral Montana, approximately 25 miles north-northwest of the City of Billings. The site is in Yellowstone County. The town closest to the proposed site is Broadview (population 133.)

The site is located in what is known locally as the Comanche Basin. This basin is shallow with its east rim at about elevation 4,000 feet, the west side approaching elevation 4,200 feet, the north and south edges at 3,800 feet and the low points within the basin at about elevation 3,750 feet.

Comanche Basin measures approximately 16 miles by 20 miles, providing 230 square miles of generally flat terrain. This site size provides considerable flexibility for both horizontal placement and rotational orientation of observatory arms. Figures included in this proposal are based on an observatory vertex located in Section 2, Township 2 North, Range 23 East, Montana Prime Meridian; other technically feasible placements and orientations within Comanche Basin are probable, and would provide substantial flexibility for site pairings.

Figure 2.1 (located in the map pocket) is a 7.5 minute USGS topographic quadrangle, depicting the generally flat but gently sloping basin topography. Figure 2.2 includes two 1:250,000 engineer's scale maps depicting the entire Comanche Basin and its relationship to the City of Billings. Figure 2.3 shows the topographic profile along each observatory arm for the initial site.

CLIMATE

The climate of Billings, Montana and the Comanche Basin is strongly influenced by the nearby Rocky Mountain, which moderate the continental type of weather. Air moving eastward from the Pacific Ocean flows over the Rocky Mountains, and when this air descends the eastern slopes of these mountains it is compressed and becomes warmer. As a result, south-central Montana enjoys a climate that is mild compared with cities of similar latitude to the east. The average January temperature in Billings, for example, is nine degrees warmer than in Minneapolis. Detailed data on temperature, precipitation, and winds are included in Volume Two - Geotechnical Appendix.

NATURAL AND MAN-MADE FEATURES

There are no significant natural features which would adversely affect this site. The area is a shallow basin, with no natural drainage outlets. Flooding is not a concern. Because

FROM U.S.G.S.
COMANCHE QUADRANGLE
Montana, Yellowstone Co.
7.5 MINUTE SERIES (TOPOGRAPHIC)

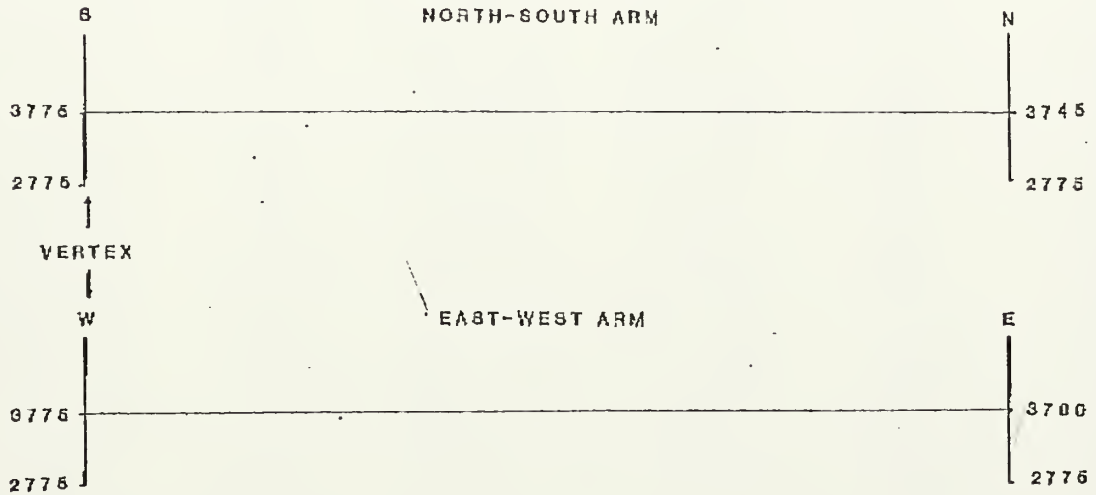
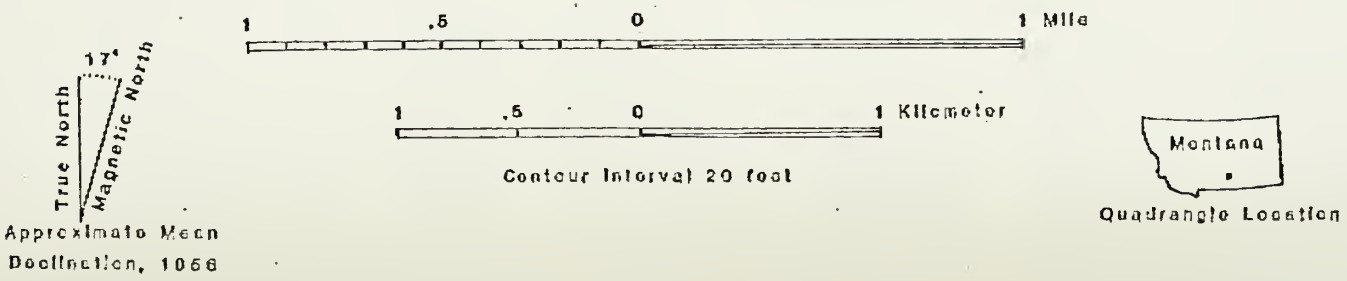


FIGURE 2.3
Topographic Profile
of Observatory Arms



rainfall is minimal in this area (about 11 inches per year), ponding within the basin is not considered a problem.

Man-made features in the area consist of approximately three dozen structures, including residences, barns, silos and sheds. The observatory may easily be positioned to avoid interference from any structure. The Burlington Northern Railroad line and State Highway 3 constitute the principal horizontal features in the area; since both occupy the same general corridor, they may be easily isolated from the observatory facilities.

GEOLOGY AND HYDROLOGY

As a result of natural processes acting over geologic time, Comanche Basin is an ideal location for the observatory. This unique area has special geologic characteristics that make it particularly suited for the facility.

Flat site topography favors efficient project layout and construction. The proportions of the site area, roughly 16 miles wide and 20 miles long, provide placement and orientation flexibility to accommodate all objectives and constraints. Orientation flexibility in particular is a major benefit to the LIGO project, since site selection is dependent on the relative orientation of paired observatories.

An exploratory drilling program in mid-1987 confirmed that the site's structural geology is simple and straightforward. Bedrock consists of flat-lying or gently dipping Cretaceous and early Tertiary sedimentary formations, predominantly sandstone and shale, characterized as "softrock." There is only a thin alluvial cover in the area.

The site's geohydrology is well-suited to construction, and presents minimum water problems. This is due to low rainfall, high evaporation and surface topography that naturally removes water from the observatory area.

STABILITY AND SEISMICITY

Although sedimentary formations at the site are relatively soft, they generally exhibit excellent stability, bearing capacity, and durability. Rock units in the experimental area can readily support the required heavy foundation loads without shear failure or significant settlement. No conditions are expected that would result in settlement or ground movement that would adversely affect facility operations.

The site is located in an area characterized by low seismicity within recent geologic time and is defined as Uniform Building Code Risk Zone 1, the lowest category of seismic

activity. Since 1869, when the records began, only five recorded earthquake events had epicenters within 100 miles of the site. These events ranged in magnitude from 2.8 to 4.0.

Known fault zones occur along the southwest margin of the site area, the largest of which is about five miles long. Literature on regional faulting suggests that the latest movement along these zones may have been post Eocene or Pliocene in age. It appears that the most recent mappable movement of the fault zone is on the order of 1.6 million years ago.

VIBRATION

The only sources of vibration in the area are Montana State Highway 3, several county roads, the Burlington Northern Railroad, and agricultural equipment. Because the area is rural and agricultural, there are fewer sources of vibration than in more populated areas.

Automobile traffic in the Basin is mostly confined to State Highway 3, which crosses the basin from Acton to Broadview. The average volume of traffic on this highway is 1450 to 1800 vehicles per day. The county roads in the basin are primarily used by farmers and ranchers in the area for access to their property. There is much less traffic on the county roads than on Highway 3. Because the county roads are generally unpaved, traffic is slower as well.

On average, one to two trains use the Burlington Northern Railroad line per day. These trains are generally about 80 cars in length and travel about 60 miles per hour as they cross the basin. The observatory placement used in the accompanying maps yields a distance of greater than two miles to the rail line; vibration should not pose a measurable problem.

The farmers in the Comanche Basin use heavy machinery, including tractors, cultivators, and combines, to cultivate and harvest their crops. Such activities probably would not take place near the observatory because of the presence of LIGO facilities in the area.

NOISE

The Comanche Basin is a rural, agricultural area which does not experience unusual levels of background noise. The principal sources of noise in the area are automobile traffic on Highway 3, train traffic on the railroad line, and noise from agricultural machinery. Noise from aircraft taking off from the Billings Airport will occasionally be audible, but since the principal corridors used by aircraft are 10 to 15 miles from the basin, aircraft noise should not be objectionable. There are no sensitive receptors such as hospitals in the Comanche Basin.

ENVIRONMENT

Based on a Preliminary Environmental Evaluation conducted for the Superconducting Supercollider Project, the impacts from siting, constructing, operating, and decommissioning the SSC would have been relatively insignificant due to the nature of the existing site environment and land use. The proposed observatory constitutes a relatively minor action in comparison with the collider; impacts are expected to be reduced by several orders of magnitude. The site does not support any known federally listed threatened or endangered species. Because the site ecosystem is not unique, it will be possible to comply with appropriate environmental requirements within reasonable limits of time and cost.

Wetlands

The U.S. Geological Survey 1:24,000-scale topographic maps show no marshes within the site. Other small surface water bodies in the internally drained basin do exhibit some features characteristic of wetlands. These water features may constitute wetlands as defined by Executive Order 11990-Protection of Wetlands (10 CFR 1022 et seq.) Confirmation of the type and location of wetlands will be completed as part of a project specific environmental assessment.

Surface Water

The LIGO facility would be located within the drainage of the Comanche Basin. Maps indicate 399 miles of intermittent streams and 25 miles of perennial small streams in the Basin. The low ratio of total stream distance to surface area of the basin, 1.84 miles/square mile, indicates the relative aridity of the basin. The intermittent streams carry water when runoff is heavy, usually during spring. Approximately one year in ten, heavy runoff causes minor flooding of some streams.

Surface water samples were taken in the summer of 1987 from four small ponds and a stream in the site area. Tests on these samples indicate high pH and high total dissolved solids (up to 8,000 mg/L) in the surface waters of Comanche Basin. These results are consistent with soil conditions, drainage patterns, and climate of the area.

Fish and Wildlife

Overall, the Comanche Basin area is not considered to be a unique or uncommon wildlife habitat; similar habitat exists in abundance in the region. The surface water resources and vegetation in the vicinity of the site provide habitat for a

moderate range of wildlife species. Agricultural activities have altered the natural habitat and influenced the kinds and numbers of species present.

Pronghorn antelope and mule deer are the predominant big-game species. There are no antelope wintering areas in the vicinity. Mule deer tend to inhabit the wooded areas and broken side slopes of drainages to the east of the site. This area, outside the site perimeter, has been identified in a 1974 study as critical mule deer habitat. More recent studies have not identified any mule deer winter ranges or year-long high density areas near the proposed site.

The most prevalent predators in the region include the coyote, bobcat, lynx, and red fox. Their incidence at the proposed site is unknown. Numerous small mammals include the jackrabbit, cottontail rabbit, prairie dog, ground squirrel, and many small rodents such as the western deer mouse.

Sage grouse are the most widely distributed and abundant game-bird species. They are primarily associated with the sagebrush communities in the grassland basin and in the pine forested area east of the site. Sharp-tailed grouse can be expected to concentrate near the ridges bordering the Comanche Basin to the east. Introduced game-bird species may occur in the area.

In wet years, Comanche Basin surface waters may attract waterfowl populations close to 100,000 for breeding and stopovers. In dry years, waterfowl breeding is limited and populations total in the hundreds. The largest breeding area within the area is the Spidel Waterfowl Protection Area, three miles northeast of Broadview, administered by the U.S. Fish and Wildlife Service.

Other wildlife in the general area include raptors, such as golden eagles and red-tailed hawks, and numerous species of passerine birds. Various reptiles and amphibians inhabit the site area.

One study of the area concluded that "the temporary ponds and marshes in the area...do not support a fishery of any importance." Any fish are likely to have been stocked. The Montana Department of Fish, Wildlife, and Parks indicates that their only fishery in the area is Broadview Pond, which they plan to manage as a bass-crappie fishery.

Vegetation

Comanche Basin is characterized primarily by mid-grass prairie, with some wetland vegetation in lowland areas and ponderosa pine cover on the rock outcroppings and broken drainage slopes outside the site's eastern perimeter.

Air Quality

Sources of air pollutants in the site area include agricultural activities which generate particulates. Petroleum refineries and a coal-fired power plant in Billings emit sulfur dioxide, nitrogen dioxide, and particulates. The Billings sources are downwind twenty miles to the southeast of the site. Dispersion modeling conducted by the State of Montana Air Quality Bureau for the Billings area indicates that no significant concentrations of any regulated pollutant should occur at that distance from Billings.

Background Radiation

The sedimentary rocks underlying the Comanche Basin contain very small amounts of radioactive elements that contribute to the low background radiation observed. There are two geologic formations under the Comanche Basin that may contain slightly elevated concentrations of uranium and other radioactive elements. These formations are the Bearpaw Shale, which locally contains deposits of bentonite, and the Virgelle Sandstone, a favorable environment for "Texas" roll-type deposits that may contain uranium concentrations.

Historical and Archaeological Resources

The Montana State Historic Preservation Office (SHPO) has identified 85 prehistoric and historic sites, mostly tipi rings and lithic scatters, within the general region of the proposed site. Only one of the recorded sites, a log hotel which once was the Antelope Stage Coach stop on the historic route from Billings to Lavina, is listed on the National Register of Historic Places.

The area has not been extensively or systematically surveyed to date and other sites may exist. SHPO believes that the recorded sites are probably representative of the range of site types that occur there. Most of the cultural resources at the recorded sites are relatively common to the general region.

POTENTIAL FOR DEVELOPMENT ENCROACHMENT

The Comanche Basin is in a sparsely populated and relatively isolated area. The nearby communities of Acton, Broadview, and Comanche are not expected to experience significant growth over

the next several decades. Growth in the Billings Metropolitan Area is occurring, but is directed away from the proposed site. No encroachment is likely to occur.

UTILITIES

Electricity

The site area is served by Montana Power Company (MPC,) a utility with an excellent balance of hydroelectric and coal-fired generation and firm power purchase agreements. In 1986, MPC's peak generation was 1,233 MW, 73 percent of its capacity. In addition, MPC is interconnected by two 500 kV transmission lines and a number of 230 kV lines to large electrical supply systems in the Northwest.

The Broadview substation interconnects seven major transmission lines 230 kV or higher, any one having the capacity to provide full-load service to the observatory. The two 500 kV lines connect the 2,060 MW Colstrip generating station and the Bonneville Power Administration's Garrison switchyard 225 miles to the west. The 230 kV lines connect Great Falls and Billings. Because of these interconnections to large power generation facilities and transmission line redundancy, the observatory could not be placed in a more stable and reliable location for power supply.

Water Supply and Wastewater Disposal

The Comanche Basin is not presently served by public water supply or sanitary sewer systems. On-site measures will be required involving a well, septic tank, and drainfield.

Permits for these facilities must be obtained through:

Yellowstone County Health Department
Room 309, Courthouse
P.O. Box 35033
Billings, MT 59107
Telephone:(406)256-2757
Telecopier:(406)256-2736

The Yellowstone County Health Department has three full-time Registered Sanitarians on staff to provide advice and permit application processing.

Preliminary indications are that potable water supply may be found at depths as shallow as 70 feet near the Comanche townsite. Exact depth will depend on well location and volume required.

Septic system size and location appear relatively straightforward. Soil tests conducted for an amended residential subdivision near the Comanche Townsite in 1983 resulted in drainfield requirements of 185 square feet per bedroom, with a 1,000 gallon septic tank. Drainfield and tank sizing will depend on number of employees, shift scheduling, and water use projections.

Solid Waste Disposal

The City of Billings operates a solid waste landfill south of the city with capacity estimated to be adequate beyond the year 2010. Contractor-operated waste disposal trucks are available for collection and transportation of solid wastes to the landfill. Low-level hazardous waste can be trucked to a licensed site in Colorado or Utah. A firm specializing in transport of this material is headquartered in Billings.

PERMITS AND ENVIRONMENTAL PROCEDURES

Building Permits

Comanche Basin is under the Building Permit jurisdiction of the State of Montana. Permit issuing authority is:

Building Codes Bureau, Public Safety Division
Montana Department of Commerce
1218 East Sixth Avenue
Helena, MT 59620
Telephone:(406)444-3933

Building permits will be required for the observatory, subject to the following standard codes as amended by Montana Administrative Rule:

1) 1988 Uniform Building Code;
2) 1988 Uniform Mechanical Code;
3) 1988 Uniform Plumbing Code;
4) 1990 National Electrical Code, and;
5) 1986 Model Energy Code.

These codes and administrative rules are available through the Building Codes Bureau.

Plumbing and electrical installations must be performed by Montana-licensed contractors.

Building Codes Bureau officials estimate initial project review for a project of this size can be completed within three weeks of receiving full plans and specifications for the project, including plumbing, mechanical, and electrical elements.

Environmental Procedures

Because Comanche Basin is the same site proposed for the Superconducting Supercollider, a great deal of environmental assessment has been completed; much of the information developed during this process is directly applicable to the LIGO Project. Since LIGO represents a much smaller and less complicated (in terms of disturbance) construction effort, many of the potential impacts associated with the SSC will not apply in the same degree for LIGO.

Montana is governed by an Environmental Policy Act (MEPA) similar to the National Environmental Policy Act (NEPA.) An environmental review of the project will be conducted; if the LIGO Project is determined to constitute a "major state action affecting the environment," an environmental assessment will be required. Environmental specialists within state government estimate that 80% or more of the work involved in such an assessment has already been completed as part of the SSC proposal.

At this time, only three environmental-related permits appear to apply. These are summarized below.

Wastewater Disposal: Discussed above, this permit will be required for the septic system used by employees. The permit is obtained through the Yellowstone County Health Department. Permit processing customarily requires less than 30 days.

Building Permit: Also described above, the permit is obtained through the Building Codes Bureau of the Montana Department of Commerce. Initial plan review should be completed within three weeks of application.

Air Quality Permit: May be required if construction activity requires installation of a batch asphalt or concrete plant. The primary regulatory concern would involve total suspended particulates generated by construction activities, which may be mitigated by a number of dust suppression measures. Once operational, the facility would not generate sufficient emissions to require a permit. This Temporary Air Quality Permit would, if required, be obtained by the construction contractor from the Air Quality Bureau, Montana Department of Health and Environmental Sciences.

THE COMMUNITIES

BILLINGS

The City of Billings is the largest in Montana, with a 1990 city population of 81,151. The city is the dominant trade center in the region, offering an excellent quality of life for resident staff and visiting scientists, as well as a dynamic business community capable of providing significant support to the LIGO project. A general map of the city is provided as Figure 3.1.

Transportation

Billings offers exceptional interurban air, rail, and highway transportation networks. Of particular interest to this project, the city is served by four major air passenger carriers providing easy, same-day service to and from both U.S. coasts. A summary of departures/arrivals by destination/origin is presented in Figure 3.2.

Intraurban transportation (within the city) is provided by a metropolitan coach line (MET) and private taxicab service. The bus system operates 17 routes between the hours of 6:15 am and 6:45 pm weekdays, with Saturday service available from 10:30 am to 3:45 pm. Service provides transportation to most work locations in the city, as well as shopping and medical centers, secondary, and post-secondary schools.

MET also provides a special service called MET-Plus for those people who cannot ride the MET buses because of a physical condition. MET contracts with a third party provider to provide this door to door service for eligible individuals.

Education

The commitment to quality education in Billings, as in all of Montana, is longstanding and fundamental. The results are evident.

The most recent composite American College Test (ACT) score in the Billings public school system was 22.1; as a state, Montana's average was 21.6; the composite Mountain/Plains Region score for the period was 21.1; the U.S. average was 18.6. Billings public school students scored in the top twenty percent nationwide on the Iowa Test of Basic Skills (ITBS.)

K-12 public school enrollment in Billings School District No. 2 (metropolitan area) for the current year is 15,379, in the following categories:

FIGURE 3.1

Map of Billings

BILLINGS

AREA CHAMBER OF COMMERCE®

815 South 27th Street • P.O. Box 31177
Billings, MT 59107-1177 • (406) 245-4111

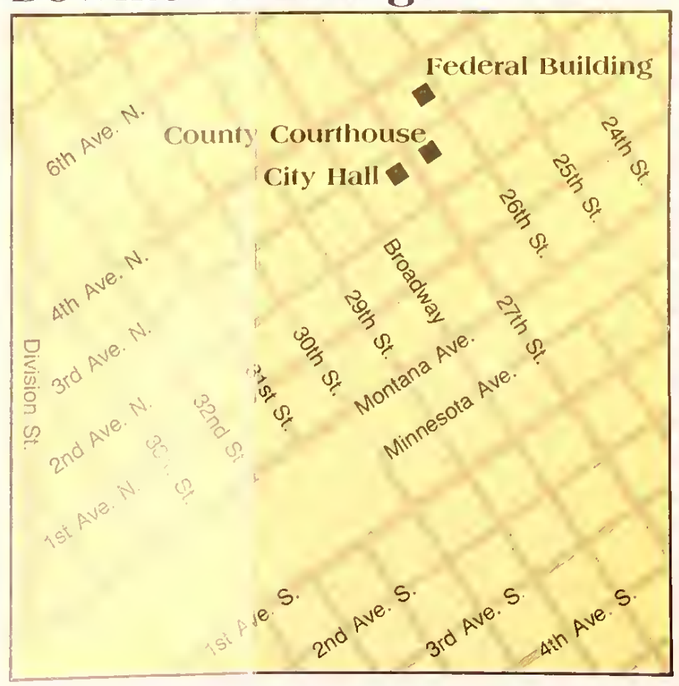
to Roundup
to Shepherd
Lake Elmo State Park
to Miles City
to Hardin
Wicks Ln.
to Ryegate
Lake Elmo Rd.
Main St.
Bench Blvd.
Billings Logan International Airport
Johnson Ln.
Zimmerman Trail
Highway 3
Alkali Creek Rd.
Highway 318
Lockwood Rd.
Lockwood Frontage
Old Hardin Rd.
MetraPark/Fairgrounds
Rimrock Rd.
Poly Drive
6th Ave. N.
4th Ave. N.
1st Ave. N.
Highway 87 E.
I-90
to Hardin
St. Vincent Hospital
Deaconess Hospital
Colton Blvd.
Parkhill Dr.
N. 32nd St.
Rehberg
19th
17th
15th
13th
12th
8th
6th
5th
Grand Ave.
Lewis Ave.
16th
Broadwater Ave.
Division St.
N. 27th St.
Montana Ave.
1st Ave. S.
Central Ave.
State St.
48th
Shiloh Rd.
32nd
24th
Monad Rd.
Daniel St
Moore Ln.
Calhoun Ln.
Orchard Ln
Hallowell Ln.
Jackson Ln
Sugar Ave.
20th
Laurel Rd.
King Ave. W.
King Ave. E.
I-90
Midland Rd.
Billings Blvd.
Frontage Rd.
Gabel Rd.
Hesper Rd.
Mullowney Ln.
River
Yellowstone
Frontage Rd
Harrish Blvd
Neibauer Rd.
Blue Creek Rd.
Wise Ln.
to Laurel

City Parks
Postal Stations

North

0 ½ 1 2
Scale in Miles

Downtown Billings



A Service of The Business Development Council

FLIGHTS TO MAJOR METROPOLITAN CITIES FROM BILLINGS, MONTANA
As of January, 1991

Billlings To:	Delta	United	Continental	Northwest	Travel Time	Costs
BOS	2 via-SLC	2 via DEN	2 via DEN	3 via MSP	7 hours	$ 456 - 1255
SLC	4 non-stop	2 via DEN	2 via DEN	N/A	1 hr 10 min	259 - 630
DEN	4 via SLC	2 non-stop	2 non-stop	N/A	1 hr 20 min	285 - 704
MSP	4 via SLC	2 via DEN	2 via DEN	3 non-stop	2 hrs	309 - 970
CHI	4 via SLC	2 Via DEN	2 via DEN	3 via MSP	4 hrs	385 - 961
OMA	2 via SLC	2 via DEN	2 via DEN	3 via MSP	3 hrs 20 min	309 - 918
SEA*	4 via SLC	2 via DEN	2 via DEN	N/A	4 hrs 30 min	313 - 744
Kansas Cty	4 via SLC	2 via DEN	2 via DEN	3 via MSP	4 hrs 15 min	331 - 918
Calgary	2 via SLC	N/A	N/A	N/A	4 hrs	445 - 700
PHX	4 via SLC	2 via DEN	2 via DEN	N/A	4 hrs	329 - 880
SFO	4 via SLC	2 via DEN	2 via DEN	N/A	4 hrs	331 - 864
LAX	4 via SLC	2 via DEN	2 via DEN	N/A	3 hrs 15 min	331 - 864
ATL	3 via SLC	2 via DEN	1 via DEN	2 via MSP	5 hrs 20 min	430 - 1164
Houston	2 via SLC	2 via DEN	2 via DEN	2 via MSP	4 hrs 30 min	405 - 1034
DFW	4 via SLC	2 via DEN	3 via DEN	2 via MSP	4 hrs	380 - 938
NYC	3 via SLC	2 via DEN	2 via DEN	3 via MSP	6 hrs	453 - 1196
PDX	3 via SLC	2 via DEN	2 via DEN	1 via SEA	5 hrs	313 - 764
LAS	5 via SLC	2 via DEN	2 via DEN	N/A	4 1/2 hrs	331 - 796
ABQ	3 via SLC	2 via DEN	2 via DEN	N/A	3 1/2 hrs	309 - 812
BUR	3 via SLC	2 via DEN	2 via DEN	N/A	3 hrs 45 min	331 - 864

SLC - Salt Lake City, DEN - Denver, MSP - Minneapolis, CHI - Chicago, OMA - Omaha, SEA - Seattle, PHX - Phoenix, SFO - San Francisco, LAX - Los Angeles, ATL - Atlanta, DFW - Dallas/Fort Worth, NYC - New York City,
PDX - Portland, LAS - Las Vegas, ABQ - Albuquerque, BOS - Boston, BUR - Burbank

FIGURE 3.2

FIGURE 3.2
(continued)

FLIGHTS TO BILLINGS, MONTANA FROM MAJOR METROPOLITAN CITIES
January, 1991

From:	Delta	United	Continental	Northwest
SLC	4 non-stop	1 via DEN	2 via DEN	N/A
DEN	4 via SLC	2 non-stop	2 non-stop	N/A
MSP	2 via SLC	2 via DEN	2 via DEN	3 non-stop
CHI	4 via SLC	2 via DEN	2 via DEN	3 via MSP
OMA	1 via SLC	2 via DEN	2 via DEN	2 via MSP
SEA	3 via SLC	1 via DEN	2 via DEN	N/A
Kansas CTY	4 via SLC	2 via DEN	2 via DEN	3 via MSP
Calgary	2 via SLC	N/A	N/A	N/A
PHX	3 via SLC	1 via DEN	2 via DEN	N/A
SFO	3 via SLC	1 via DEN	2 via DEN	N/A
LAX3	4 via SLC	2 via DEN	2 via DEN	N/A
ATL	4 via SLC	1 via DEN	2 via DEN	2 via MSP
Houston	3 via SLC	2 via DEN	2 via DEN	2 via MSP
DFW	4 via SLC	2 via DEN	2 via DEN	2 via MSP
NYC	4 via SLC	1 via DEN	2 via DEN	3 via MSP
PDX	3 via SLC	1 via DEN	2 via DEN	N/A
LAS	3 via SLC	1 via DEN	2 via DEN	N/A
ABQ	3 via SLC	1 via DEN	2 via DEN	N/A

FIGURE 3.3
Billings School District Enrollment
by Grade

Grades	Students
Kindergarten	1,273
1 - 6	7,062
7 - 8	2,090
9 - 12	4,443
Special Education	511

With 25 elementary schools, four junior high schools, and three high schools in the public system, students can still receive individual attention.

Billings also possesses a strong private education community, with 19 private pre-schools and kindergartens and eight other elementary and secondary institutions.

Education in Billings does not stop at the high school diploma. The city is home to Eastern Montana College (EMC), the third largest unit in Montana's six unit university system. EMC currently has an enrollment of approximately 4,000 students studying a variety of fields, including Arts and Sciences, Education, Business, Human Services, and some professional areas. Eastern offers the two-year Associate of Arts and Associate of Science; four-year Bachelor of Arts and Bachelor of Science degrees in Arts and Sciences, Business and Education; Bachelor of Science in Human Services; and Master's degrees in Education.

Master of Education degrees have options in Early Childhood Studies, Educational Computing, General Curriculum, Reading, School Counseling and Secondary Education with minors in Business Education, History, Mathematics (5-9 Middle School) and Music; Master of Science in Special Education degrees offer options in Emotional Disturbance, Learning Disabilities, Multi-Handicapped, and Personnel and Guidance Services. Eastern also offers a Master of Science in Rehabilitation Counseling.

EMC is fully accredited by the Northwest Association of Schools and Colleges. It is accredited by the National Council for the Accreditation of Teacher Education for the preparing of elementary and secondary teachers through the Master of Education degree and Master of Science in Special Education degree, and by the National Association of Schools of Music, the National Association of Schools of Art and Design, and the Council on Rehabilitation Education.

Rocky Mountain College (RMC) is a private, four-year, fully accredited liberal arts church-related college, with a population

of 758 students. Rocky professors hold credentials from Harvard, Northwestern, Cornell, Cambridge, Columbia, Syracuse, and Chicago Universities, and use the college's 15:1 student/teacher ratio to guarantee individual attention and instruction.

Rocky offers programs in 26 fields of study, including: Art; Aviation Studies; Biology; Chemistry; Computer Applications; Computer Science; Economics and Business Administration (Accounting, Management;) Elementary Education; English; Equestrian Studies; Geology; History and Political Science; Mathematics; Philosophy and Christian Thought; Psychology; and many others. The college also offers pre-professional programs in Dentistry, Engineering, Occupation Therapy, Lay Medicine, and Physical Therapy.

The Billings Vocational Technical Center (BVTC) was established in 1969 to provide education and training in technological competencies through industry-validated curricula. BVTC's focus is on certificate programs not exceeding two years in length, as well as continuing adult education and custom designed courses for Eastern Montana employers.

Billings is also host to at least nine trade/industrial schools offering programs in beauty and cosmetology, modeling, business, aviation, broadcasting, and auctioneering.

Billings parents may also choose from a variety of day nursery and child care options. The city has 24 private centers, offering traditional, Montessori, and religious instruction.

Shopping and Dining

As the dominant trade center in the region, Billings is a mecca for shopping and dining. It is common for regional residents to travel 200+ miles (one way) for a day of shopping in the City. This large drawing area supports a wide variety of retail shops and dining establishments.

The City's 13 principal shopping areas contain over 500 retail stores, offering all manner of goods. These shopping districts include: the downtown area, with over 200 shops; Rimrock Mall, with over 100; Homestead Mall, with 40 shops and restaurants; West Park Plaza, with 50 stores, and; several neighborhood shopping centers.

With over 180 dining establishments, the City's fare will satisfy any palate. Cuisine runs the gamut from fast food and "home cooking" through fine Italian and Oriental offerings.

Medical Care

Billings' medical community provides the most advanced health care services in a four-state area. Two modern and fully-accredited hospitals, sixteen clinics, and hundreds of physicians offer every major medical specialty and provide a complete range of medical-surgical services and emergency care. Specialized emergency transport with helicopter, fixed-wing airplane, and ground ambulances provide advanced life support systems. Numerous free health awareness programs strive to educate the public in preventative, as well as curative, health care.

Deaconess Medical Center and St. Vincent Hospital and Health Center form the center of the city's medical corridor which encompasses approximately 35 blocks and 114 acres. Twenty different health-related facilities exist in the medical corridor, with numerous support facilities located in other parts of the city.

Deaconess' areas of specialty include the William F. Welch Heart Center, Cancer Services, Phillip Fortin Intensive Care Units, Neuroscience services, Northern Rockies Kidney Center, Deaconess Psychiatric Center, Pulmonary Services, Orthopedic Services, Charles M. Bair Family Memorial Emergency Trauma Center, and the recently opened Deaconess Research Institute.

St. Vincent's is a private, not-for-profit organization. The hospital provides comprehensive inpatient and outpatient services in cardiology, orthopedics, general internal medicine, pediatrics, emergency and trauma, neurosciences, rehabilitation, neonatology, oncology, senior services, and women's services.

Billings is also home to major facilities offering services in mental health, chemical dependency, and cancer treatment.

Housing

Housing opportunities in Billings are comparatively affordable, and generally provide greater square footage and amenities when compared to cities of similar sizes in states not affected by the energy slowdown. The October, 1990 inventory of single-family homes in the Multiple Listing Service totalled approximately 820. The average listed price for a three bedroom home is $69,200, while the average for all residential properties was $72,500. The average residential sale price for 1990 was $65,100. A summary of Multiple Listing Service listings is shown in Figure 3.4.

A great variety of locations are available for the individual consumer. Older, established "traditional" neighborhoods are complemented by new subdivisions, country acreages, golf course housing, and suburban communities.

FIGURE 3.4

SINGLE FAMILY HOMES, CONDOS AND TOWNHOUSES AVAILABLE THROUGH MULTIPLE LISTING SERVICES OCTOBER 1990

PRICE RANGE	BILLINGS	
	METRO	COMMUTING*
$ 20,000 - $ 40,000	92	95
40,000 - 50,000	79	32
50,000 - 60,000	89	21
60,000 - 70,000	64	28
70,000 - 80,000	41	17
80,000 - 90,000	34	18
90,000 - 100,000	36	14
100,000 - 125,000	39	17
125,000 - 150,000	20	10
150,000 - 200,000	24	12
200,000 AND UP	9	9
TOTALS	527	273
	TOTAL 800	

*Includes Residential with acreage

Source: Billings Multiple Listing Service, October, 1990

Culture, Libraries, and the Media

THE ARTS

The fine arts flourish in Billings. Each season the Billings Symphony Orchestra and Chorale presents ten outstanding concerts to the community. Offering a wide variety of works, composers and soloists, the yearly program of the 70-member orchestra includes eight regular concerts with at least two including the 80-member chorale, a free childrens' concert, and an annual free concert in the park. Every other year the Symphony presents the Young Artist Award concert which has been of great benefit to many talented musicians in the region.

The Fox Committee for the Performing Arts contributes to the city's lively culture with an average of 12 events per year. Programs range from jazz to ballet and from folk and western music to professional opera. Each fall, the group also produces a holiday musical. Recent performances sponsored by the Fox Committee include the Ray Charles Show, American Indian Dance Theater, Trisha Brown Dance Company, Dance Brazil, and Broadway musicals "Into the Woods," "Hello Dolly" and "The Music Man."

One of the most successful groups who sponsor live performances in the city is the Billings Community Concert Association. Over the years, concerts have reflected a variety of musical styles from folk to chamber music, and jazz to classical symphony. Noted performers have included Jascha Heifitz, Marion Anderson, Yehudi Menuhin, Peter Nero, Nelson Eddy, The Boston Pops, Metropolitan Opera tenor Enrico di Guiseppe, and Marion McPartland, to name a few.

Billings Studio Theatre is a major producer of live theater in Montana. Each season, six productions plus two summer repertory presentations are offered to audiences, which include everything from Shakespeare to Neil Simon. Recent productions include "Annie," "Taming of the Shrew," and "Inherit the Wind." The Billings Studio Theatre also offers three children's theater productions each year.

The Alberta Bair Theater for the Performing Arts is the only major performing arts center in the region. Formerly the Fox Theater, the four million dollar renovation project has provided Billings with a theater that offers a wide range of programs - from children's programs to country music, local amateur productions to symphony concerts.

For sheer fun, Billings boasts three dinner theaters, long popular with residents and tourists alike.

Accredited by the American Association of Museums, the Yellowstone Art Center annually shows 16 to 20 exhibits of national and regional contemporary and historic art. Drawing its audiences from a four-state region, the Center's innovative program also includes a lecture/concert series featuring nationally known art critics, art historians, and artists. Yellowstone Art Center also offers chamber music and jazz concerts throughout the year. Of particular pride is the Center's growing collection of regional contemporary art - the only one of its type in a four-state region.

The Western Heritage Center is a nonprofit regional museum of history which strives to preserve the past through changing exhibits, educational programs and special events illustrative of the rich cultural heritage of this area.

Fascinating relics of pioneer and Indian life may be seen at the Peter Yegen Jr. Museum. Specimens of birds, animals, rocks, and fossils native to this region are also on display.

That's not all. Over a dozen local art galleries feature works of all types by regional and national artists. Eastern Montana College and Rocky Mountain College further enrich the community with concerts, plays, and art exhibits. The Yellowstone METRA building, with up to 12,000 seats, regularly schedules concerts, stage performances, rock groups, orchestras, ice shows and much more.

LIBRARIES

Billings is proud of the quality of its libraries and the many services they offer. Both the Parmly Billings Library and the Eastern Montana College Library have excellent reference departments and collections. Useful services and a tremendous amount of information are available to enrich the reader.

The Parmly Billings Library is the largest public library in a four-state area, and provides a variety of informational and recreational services to its patrons. Residents of Yellowstone County may make free use of the Library by checking out any of the 272,917 books in its collection, by making use of the scores of periodicals and out-of-town newspapers to which it subscribes, or by bringing children to any of its numerous children's programs.

Each of the Library's departments offers its own special services. The Youth Services Department provides fiction and nonfiction books for elementary and junior-high school students, as well as hundreds of picture books for preschool children. A highlight of this department is the creative and original story hours offered to children and their parents.

The reader who enjoys fiction will have the largest fiction collection in the state to choose from. The Fiction Department is staffed by a full-time librarian who assists patrons in making selections and who makes sure that copies of all the latest best sellers are available.

For those interested in Montana history, there is the Montana Room, whose shelves are full of many one-of-a-kind books on the history of the state. Here one can also find a large collection of materials on the Custer Battle, files on all aspects of Montana history, as well as a collection of old and rare photographs of early Billings and its settlers.

The second floor of the Library houses the nonfiction collection and the Information Department. Staffed by four librarians, this Department answers thousands of questions each month. Its collection specializes in world-wide reference materials and in such diversities as extensive business and investment directories, automobile repair manuals, and genealogical materials.

The Eastern Montana College Library is open to the public seven days per week. This library boasts an exceptionally strong collection of magazines and journals of interest to business persons, as well as housing a Federal and State Documents Repository. Of course, the library has full collections in support of the college's array of studies, from the arts to zoology.

The Paul M. Adams Memorial Library at Rocky Mountain College is also open to the public during academic sessions. This library's collection of 65,000 volumes is strongest in geology, music, philosophy, and religion.

THE MEDIA

Billings is well served by all forms of the media. The city enjoys the services of one daily newspaper, five weeklies, two bi-weeklies, and one monthly.

The city has three local television stations covering all major networks, plus an additional 29 channels available via cable.

The city is also home to four AM band radio stations and eight FM stations.

Human Resources

The steady growth of Billings over the past 35 years has resulted in a constantly expanding labor pool. The source has

been local as well as in-migration, the latter being attracted to the city by its continually expanding employment base. The following tables provide data on labor and employment conditions in Billings.

FIGURE 3.5
Employment and Unemployment Data
Billings Metropolitan Statistical Area
1985-1989

	1985	1986	1987	1988	1989
Civilian Labor Force	61,790	61,436	60,085	58,962	61,870
Employed	57,290	56,726	55,704	55,321	58,704
Unemployed	4,500	4,710	4,381	3,641	3,116
Rate	7.3%	7.7%	7.3%	6.2%	5.1%

FIGURE 3.6
AVERAGE EMPLOYMENT BY INDUSTRY
YELLOWSTONE COUNTY
1989

Mining and Construction		1,800
Manufacturing		3,200
Transportation, Communication, and Public Utilities		3,900
Trade		17,000
Wholesale	4,900	
Retail	12,100	
Finance, Insurance, Real Estate		2,700
Services		14,000
Government		7,600
Total Non-Agricultural Wage and Salary Employment		50,200
All other employment (two largest components are agriculture and self-employment)		5,449
Total Employment		55,649

Source: Montana Department of Labor and Industry

FIGURE 3.7
1989 WAGE INFORMATION
Yellowstone County

Industry	Average Weekly Wage Per Employee	Average Quarterly Employment
Average: All industries	$369	50,326
Private Business	362	42,796
Agriculture:		
Agri-Production, crops	287	50
Agri-Production, livestock	244	87
Agricultural Services	247	145
Mining:		
Oil and gas extraction	676	312
Construction:		
General Building	418	315
Heavy Construction	420	298
Special Trades	427	1,015
Manufacturing:		
Food Products	444	1,029
Lumber	250	71
Furniture	392	53
Printing	385	661
Petroleum Refining	708	725
Stone, Clay, and Glass	398	149
Metal Fabrication	412	179
Machinery (non-electric)	374	109
Transportation and Communication:		
Local Transportation	278	234
Trucking and Warehousing	497	1,426
Air Transportation	441	393
Transport Services	285	100
Communication	471	753
Electricity/gas/sanitation	579	345
Wholesale Trade:		
Durable Goods Handlers	460	2,974
Nondurable Goods Handlers	501	2,090

Figure 3.7 (continued)

Retail Trade:		
Building Materials	359	445
General Merchandise	192	1,732
Food Stores	237	1,519
Auto Dealers	364	1,629
Apparel and Accessories	174	561
Furniture and Furnishings	345	569
Eating and Drinking Establishments	127	4,476
Finance, Insurance, and Real Estate:		
Banking	378	1,119
Credit Agencies	544	115
Security and Commodity	794	157
Insurance Carriers	535	192
Insurance Agents and Brokers	454	375
Real Estate	313	497
Services:		
Hotels and Lodging	191	754
Personal Services	206	547
Business Services	236	1,780
Auto Repair	295	572
Miscellaneous Repair	348	351
Motion Picture Operations	130	222
Amusement and Recreation	176	600
Health Services	480	5,375
Legal Services	788	476
Educational Services	286	329
Social Services	220	1,127
Government:		
State	424	1,126
Local	340	4,538
Federal	568	1,866

Source: Montana Department of Labor and Industry, Research and Analysis Division 4th Quarter 1989 Report

Note: The wage information shown above was gathered at the 2-digit SIC level from unemployment insurance reports.

Recreation

Billings, like all of Montana, offers outstanding recreational opportunities. Situated along the historic and picturesque Yellowstone River Valley, the city offers access to a variety of outdoor options.

There are many historic points of interest in the Billings area. Most of these areas hold stories of the frontier past. Pictograph Cave State Monument, for example, bears images of shield-bearing warriors, human-like figures, and animals, all painted on the rock walls by aboriginal people thousands of years ago. Boothill Cemetery Monument holds the grave of Muggins Taylor, the army scout who carried the news of General Custer's defeat to the world.

During temperate months, the River and several area lakes and reservoirs are inviting for all manner of water-based activities from premier fishing and sailing to simply floating along. The Beartooth Mountains, located just an hour south of Billings, beckon with miles of trails and alpine lakes.

In the winter, outdoor activities never slow down. Montana's dry climate produces some of the finest powder snow in the nation; it creates a new playground for residents and tourists alike.

With the 1930s construction of the Beartooth Highway, described as one of the most "scenic spectacular roads in the world," Red Lodge became a northeast entrance to Yellowstone National Park. Twenty odd years later, skiing arrived.

Just 60 miles southwest of Billings, Red Lodge Mountain offers over 500 acres of the most diverse terrain to be found anywhere. Lazy M, a 2 1/2 miles cruiser; Drainage, 1,600 super steep vertical feet plunging through chutes, glades, and powder parks; Miami Beach, 50 sunny and gentle acres just for beginners; and 27 other great slopes. Trails cover 25 miles and are classed as 15 percent novice, 60 percent intermediate, and 25 percent expert.

Big Sky of Montana, located just 185 miles west of Billings (and just south of Bozeman) is a world class ski resort, with over 55 miles of trails, outstanding lodging and dining, and a brand new, state of the art convention center.

For the active individual, sporting facilities abound in Billings. The City operates 32 tennis courts in eight city parks; there are six golf courses in the area to challenge everyone from beginner to professional. A number of private health clubs offer every modern technology and method for fitness. Organized leagues in a variety of sports offer residents a choice of competitive outlets.

Spectator sports include the Billings Mustangs (professional rookie league baseball team, affiliated with the Cincinnati Reds,) American Legion baseball, Little and Senior League baseball, National Rodeo Association and Montana Rodeo Association sanctioned events, and horse racing (with pari-mutuel wagering.)

BOZEMAN

Bozeman, a thriving community of 30,000 in the Gallatin Valley of Southcentral Montana, is home to Montana State University (the largest of Montana's six university system units.) For LIGO, Bozeman will serve as an important supplier of scientific research capacity and technical support (see Section IV and the technical appendices for full descriptions of MSU faculty and area vendors.)

Since project researchers and observers will, from time to time, require access to university faculty and physical resources, Bozeman is described here in brief form.

Transportation

Gallatin Field, located just 10 minutes from downtown Bozeman, is one of the busiest airports in Montana. Figure 3.8 provides a detailed description of flights and times to various cities. With four major national carriers plus a regional commuter line, access to and from Bozeman to Billings and both U.S. coasts is convenient and quick.

Bozeman also lies in the Interstate 90 corridor, which traverses the Northern United States. Billings is 142 miles east of Bozeman (just over a two-hour drive.)

Education

The Bozeman Public School System takes a back seat to none in meeting the needs of today's students. In Fall, 1992, the school district is scheduled to open a Science and Technology Magnet School to serve these special needs. The Magnet School will also provide outreach and resource services to other schools in the district, in cooperation with several departments at MSU.

Bozeman's investment in education is clearly paying off; "Life in America's Small Cities" recently documented Bozeman as having the sixth most educated work forces in the nation. The U.S. Department of Education's Secondary School Recognition Program recognized the city as having one of the best high schools in the country.

The Bozeman High School dropout rate of 2.8% is among the lowest in the nation for public high schools. More than 65% of the graduates continue their education after high school, with more than 50% receiving financial assistance to do so. The 1990 graduating class of 268 students received 138 scholarships for higher education.

FIGURE 3.8

FLIGHT SCHEDULES

Bozeman To Billings			
	8:20 A.M.	8:55 A.M.	Northwest
	11:25 A.M.	1:05 P.M.	Horizon
	3:15 P.M.	3:51 P.M.	Northwest
Billings To Bozeman			
	11:10 A.M.	11:53 A.M.	Northwest
	9:15 P.M.	9:50 P.M.	Northwest
Bozeman To Boston			
Bozeman/SLC/Boston	7:10 A.M.	3:45 P.M.	Delta
Bozeman/Minn./Boston	8:20 A.M.	4:57 P.M.	Northwest
Bozeman/Minn./Boston	8:20 A.M.	6:00 P.M.	Northwest
Bozeman/Denver/Boston	8:45 A.M.	4:57 P.M.	Continental
Bozeman/SLC/Boston	2:40 P.M.	10:40 P.M.	Delta
Bozeman/Minn./Boston	3:15 P.M.	12:14 A.M.	Northwest
Bozeman/Denver/Boston	4:25 P.M.	1:45 A.M.	Continental
Boston to Bozeman			
Boston/Minn./Bozeman	6:30 A.M.	11:53 A.M.	Northwest
Boston/SLC/Bozeman	7:00 A.M.	1:35 P.M.	Delta
Boston/Denver/Bozeman	8:25 A.M.	2:03 P.M.	Continental
Boston/Denver/Bozeman	2:50 P.M.	9:19 P.M.	Continental
Boston/Minn./Bozeman	3:05 P.M.	9:50 P.M.	Northwest
Boston/Minn./Bozeman	4:15 P.M.	9:50 P.M.	Northwest
Boston/SLC/Bozeman	5:06 P.M.	10:30 P.M.	Delta

FIGURE 3.8
(continued)

	DEPARTURE	ARRIVAL	AIRLINE
Bozeman to Burbank			
Bozeman/SLC/Burbank	4:15 P.M.	9:55 P.M.	Delta
Bozeman/Denver/Burbank	4:25 P.M.	9:55 P.M.	Continental/Delta
Bozeman/SLC/Burbank	6:00 P.M.	9:55 P.M.	Delta
Burbank to Bozeman			
Burbank/Denver/Bozeman	6:40 A.M.	2:03 P.M.	United/Continental
Burbank/SLC/Bozeman	8:35 A.M.	1:35 P.M.	Delta
Burbank/Denver/Bozeman	2:52 P.M.	9:19 P.M.	United/Continental
Burbank/SLC/Bozeman	4:30 P.M.	10:30 P.M.	Delta
Bozeman to LAX			
Bozeman/SLC/LAX	7:10 A.M.	9:45 A.M.	Delta
Bozeman/Denver/LAX	8:45 A.M.	1:51 P.M.	Continental
Bozeman/SLC/LAX	2:40 P.M.	5:10 P.M.	Delta
Bozeman/SLC/LAX(not Sat)	4:15 P.M.	7:10 P.M.	Delta
Bozeman/Denver/LAX	4:25 P.M.	8:19 P.M.	Continental
Bozeman/SLC/LAX	6:00 P.M.	8:54 P.M.	Delta
LAX to Bozeman			
LAX/Denver/Bozeman	6:20 A.M.	2:00 P.M.	Continental
LAX/SLC/Bozeman	7:15 A.M.	12:12 P.M.	Delta
LAX/SLC/Bozeman	12:45 P.M.	5:20 P.M.	Delta
LAX/Denver/Bozeman	3:45 P.M.	9:19 P.M.	Continental
LAX/SLC/Bozeman	5:45 P.M.	10:30 P.M.	Delta
Ontario to Bozeman			
ONT/Denver/Bozeman	3:45 P.M.	9:19 P.M.	Continental

flight schedules 1/25/91

The current enrollment for the Bozeman School District is 4,476 students. Two new elementary schools are under construction as well as a major addition to the high school. All three projects will be completed for the 1992-93 school year.

Community Life and Amenities

The Gallatin Valley is widely known for its natural beauty and clean air. Bozeman residents also enjoy low crime rates, cultural and recreational opportunities in abundance, proximity to national parks and wilderness areas, and a healthy embrace of new ideas and technology.

"Life in America's Small Cities" acknowledged Bozeman as one of the top 100 "micropolitan" places. "Outside" magazine recommends Bozeman as one of the best 15 sports and recreation cities in the U.S.

Long known as the gateway to Yellowstone National Park, Bozeman offers some of the world's best fly fishing, cross-country skiing, hunting, hiking, camping, canoeing, and kayaking. Two downhill ski areas which accommodate skiers of all levels are within 45 miles of Bozeman. Both have average annual snowfall exceeding 300 inches which provides ideal powder and packed powder conditions form December through April.

Access to outdoor recreation is particularly easy from Bozeman. Only a 1-minute drive from downtown is the Hyalite Recreation Area, which provides opportunities for fishing, hiking, canoeing, and camping. The area also contains the Hyalite Challenge, a nationally-recognized program which provides handicapped accessible trail systems and fishing piers. These facilities are specifically designed to accommodate the special needs of people with disabilities, families with small children, and senior citizens.

Bozeman offers a diversity of cultural amenities usually found only in larger urban areas, including fourteen art galleries, a community symphony and choir, a resident Shakespeare troupe, and the annual Intermountain Opera Association performance which features Metropolitan Opera stars. Annual events include the College National Finals Rodeo, the Adult Chamber Music Festival, and the Sweet Pea Festival of the Arts.

Tourism and recreation are major contributors to the steady growth of the Bozeman community over the past decade. More than 1,000 hotel rooms, 50 restaurants, and a new conference convention center just south of Bozeman at Big Sky Resort provide accommodations for both business and vacation travelers. Additionally, satellite teleconferencing service is available through KUSM-TV, Montana's public television station located on the Montana State University campus.

TECHNICAL SUPPORT

Research

Montana State University (MSU) at Bozeman is the largest of the state's six university system units, with a current enrollment of over 10,000 students. MSU maintains its roots in the land-grant tradition of research, and has grown into a comprehensive university with increased emphasis on research. Over the past decade, in fact, research capability and faculty participation have increased over 62%.

In 1989, MSU had $15.7 million in sponsored research and expenditures in addition to its operations in eight Agricultural Research Centers. The growth and development of the University's research is reflected in the 1990 National Science Foundation decision to establish a $7.2 million National Engineering Research Center at the school; the Center will specialize in biological and chemical process analysis. Other major installations at MSU include the Center for Research in Surface Science and Submicron Analysis; the Molecular Beam Epitaxy facility; ion beam laboratory; laser spectroscopy laboratory; Advanced Materials Center; nuclear magnetic resonance laboratory, and; the GRAIL facility for graphics and image analysis.

Montana State University supports major efforts in Physics, and in particular the Physics of interest in this observatory. This commitment to astrophysics, relativity, and gravity dates back to the 1950's; the group has continued to grow in number and reputation. MSU now has one of the strongest relativity and astrophysics groups in the U.S.; this observatory fits naturally with a major academic interest in Montana.

The gravitation theory group at MSU began with the hiring of Professors Kenneth Nordtvedt and William Kinnersley. The group was enlarged in 1984 with the addition of Professors William Hiscock and Lee Lindblom. This group has established an international reputation for research in gravitation theory.

Professor Nordtvedt's research interests revolve around the calculations of relativistic gravity aimed toward finding new experimental tests of relativity theories, solar system orbits, and cosmological effects. Professor Hiscock is presently investigating the evolution of charged black holes, gravitational particle creation in the early universe, and the gravitational effects of objects such as magnetic monopoles and strings. Professor Lindblom carries out research at the interface between gravitation theory and astrophysics. Recent work has included

the investigation of gravitational radiation driven instabilities that limit the rotation rate of rapidly rotating neutron stars. Additional information on the interest and qualifications of these faculty can be found in Volume Three of this application, "University and Vendor Support Appendix."

In support of the LIGO Project, MSU proposes the addition of two faculty positions focusing on the Physics of interest in this project. These positions are also described in Volume Three of this application.

Approval for these faculty positions must come from the Board of Regents and the Montana Legislature. Subject to the selection of a Montana location for the observatory, this approval process will occur during either a regular or special session of the Legislature.

Educational Outreach

MSU is also home to the Museum of the Rockies/Taylor Planetarium. The Museum is a University, community, and state-supported institution dedicated to the interpretation of the physical and cultural heritage of the Northern Rocky Mountains. It is internationally know for its paleontological research. Among the Museum's most intriguing works are its research into the rearing of infant dinosaurs and the excavation of a complete tyrannosaurus rex. In April of 1989, the Museum opened its planetarium as part of a $6.5 million expansion; the Planetarium is one of only six of its kind in the United States.

Museum Director of Education David Swindle has identified a number of opportunities for educational outreach in conjunction with the LIGO. These opportunities are targeted toward several goals, including:

-providing the lay public with basic and intriguing information on the LIGO project;
-utilizing the LIGO project to enhance University teaching and research;
-raising the general interest and understanding of modern physics, and;
-assisting visitors in locating other scientific and cultural activities in the region.

Director Swindle's initial proposals include multi-media public access interpretive exhibits; panels and demonstrations regarding the observatory's purpose, principals, and potential implications; display of paleontological and archaeological specimens recovered during LIGO construction excavation; remote videoconferencing to participating educational institutions, and;

video productions introducing and exploring the LIGO project for a variety of national and international audiences. Additional opportunities are available if public access to the LIGO campus is available, including field trips, interpretive trails, and student "science camps."

Certain of these activities may be carried out at the Museum's facilities on the MSU campus; others may be appropriately conducted at the LIGO facility or at one of the many facilities existing in Billings.

The Private Sector

Montana offers a wealth of scientific and technological strength belying the widely-held perception of the state as a primitive culture. Commercial and industrial firms choosing to operate in and from Montana adopt and advance new technologies at a rapid rate.

Because LIGO relies heavily upon laser technologies, Montana is an outstanding choice for observatory location. Many leading firms in the industry are located in the Bozeman area, including ILX Lightwave, Toomay-Mathis Associates, and Lattice Materials Corporation (please see "University and Vendor Support Appendix" for more complete descriptions.) In addition, Montana hosts a wide variety of vendors providing advanced goods and services including: design/construction of special purpose facilities; software development; precision machining; electronics prototype manufacture and assembly, and; remote sensing devices.

Volume Three of this application also includes:

1) a list of technology-related firms in the Billings area;

2) a state-wide industry profile of firms providing goods and services in advanced technologies, and;

3) letters from three Montana laser firms supporting the Montana location of a LIGO Project observatory.